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Programmed Instruction in the Light of
Anticipated Computer Technology

by

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I. Introduction

During the past several years, I have been experimenting with programmed instruction in the area of managerial accounting. I have attempted to program certain basic fundamentals of accounting in order to relieve our basic managerial accounting course of a lot of prerequisites and therefore introduce some more advanced material. After extensive analysis of the results and after three revisions of the program, I am convinced that programmed instruction can play a significant educational role in our schools. The results strongly suggest that, through programmed learning techniques, the time required by the students to learn a given amount of material can be extensively cut and not impair retention. In fact if anything it appears that overall performance is improved.¹

The rate of experimentation and introduction of new techniques in the field of education has not been very spectacular. With programmed instruction in particular, most of the potential remains to be exploited. This is

^{*}This paper was presented at Babson Institute, Seminar on Innovations in Accounting, December 3, 1966.

¹We have carried out controlled experiments and considerable statistical analysis of the results to be convinced that programmed learning works. In our case we send the program to students ahead of time and when they arrive at school we have only review sessions on the material covered by the program. This, however, is not the only way one can use programmed instruction.

true in terms of both what we can do today with the present state of knowledge in the area of programmed instruction as well as in using it as a springboard toward new developments. What I want to say is that, and even if, there are no more developments in this area in the future, with the present state of programmed instruction technology and of the devices, mechanical or otherwise, to implement it, we have a long long way to go before we exhaust all the potentials of programmed instruction. Now, if on top of that we project ourselves into the future and speculate on new developments in the area of information technology, then we will find that we are entering into an exciting era which holds in store many challenges for the educator. I hope to convince you of this by the end of this session.

II. Claimed Advantages of Programmed Instruction

A lot has been written of the desirable attributes of programmed instruction. Among the advantages claimed most often, one can include that:

1. Programmed instruction allows the slow student to proceed at his own pace without impeding the progress of those who can absorb the material faster.
2. The student, if provided with a programmed text, can resort to it for review at any time and refresh his memory of the material covered.
3. Programmed instruction provides a logical step by step approach to the subject matter and therefore enables the students to get a firmer grasp of the material covered and also retain it longer.

I might add here that from my experience, I believe that the educational advantages do not stay with the student alone. We, as instructors, have a lot to learn, once we attempt to program the material that we teach. Often glaring inconsistencies and gaps in our logic appear which otherwise would not have been obvious in our lectures, at least to ourselves.

4. Programmed instruction relieves the instructor of the drudgery of teaching material that is very well known to him. Many times we find ourselves having to teach prerequisite courses, courses which we have taught for many years and from which we derive no challenge. If we succeed in programming the material which does not challenge us any more, because we succeeded in exhausting all the innovations that we can achieve, then we will be free to introduce to the class material which is more challenging. Normally the latter material is full of ambiguity and of speculative nature, and which challenges our ingenuity and imagination. This material, incidentally, is something that the students also look for, especially when they have the fundamental prerequisites.

I must admit that my original motive in experimenting with programmed instruction was not altruistic at all. I somehow convinced myself that a lot of the fundamentals of accounting theory were not worth of college classroom time, but on the other hand were necessary prerequisites. I wanted therefore to find some way of getting rid of them, but not of the background knowledge. Furthermore, I wanted to introduce some new material which I felt the student should have especially since at our school, the Sloan School of Management of MIT, the students are not required to take more than one accounting course. In order, therefore, to cram more material in a one-semester course without arousing the wrath of the students, I had to find ways of re-organizing the material and presenting it in a more efficient way. This in short was what prompted me to start experimenting.

The above advantages that we claim for programmed instruction seem to be more or less accepted, at least by those who advocate programmed instruction. For me, however, as I was proceeding along, it became obvious that the greatest potential benefit of programmed instruction does not lie in the above reasons, but in the area of management of the educational process. By this I mean using programmed instruction as an aid to managing our educational

resources more efficiently. Soon I will try to explain how I propose that we approach this subject. But right now let me deal with some of the symptoms of educational mismanagement.

III. Programmed Instruction and the Management of the Educational Process

I am sure that you will not be surprised if I say that a lot of our students today feel estranged to the university environment. There is some type of alienation. The students feel that they somehow do not understand what is the purpose of education and especially what is the purpose of the required curricula that we force upon them. Many of the failures at our universities, of otherwise exceptionally bright students, are attributed to a great extent to this sense of frustration and lack of purpose, and in my estimation, the real reason behind this frustration is the lack of integration of our curricula.

Our educational system rests on the notion of integrated programs of study. The people who design curricula attempt to look at the total requirements toward a goal (the degree) and then proceed toward the description of specifications which will enable the student to reach his goal. Between the design and implementation, however, there is a great gap. In practice, we do not and most often cannot present our material in an integrated fashion. Instead we compartmentalize the educational process. We expose the student to a series of what we consider as core courses, we present them as entities which can stand on their own feet independently and yet we expect him to integrate the knowledge that he gets in a compartmentalized fashion and see a forest out of the many trees. This, incidentally, becomes more apparent in the area of management where we are aiming toward the overall

firm but yet we are presenting to the student a compartmentalized curriculum with all sorts of functional and basic discipline subjects presented as independent of each other. I must readily admit that I do not believe we as teachers can be the greatest specialists in our fields of concentration and at the same time the most competent generalist to integrate all other material around our own course. Obviously we have our limitations.² But so does the student, in fact more so.

The realization that we are exposing the student to what appears to him to be a hodgepodge or at best a smorgasbord of courses, prompted me to ask the question as to how we can integrate the material that we want to disseminate. And, I felt that programmed instruction can be of great help to us in this area.

Another difficulty we find in our daily educational activities lies in the reconcilliation between the introduction of new material in the courses and the extension of the student's time toward graduation. Obviously, we cannot introduce continuously new material and expect the student to graduate within the regularly prescribed time period unless we somehow innovate and render other material obsolete. If, of course, the old material is not obsolete but we have just generated new knowledge, for which the previously taught material is a prerequisite, then the alternative to extending the number of years that it takes for a student to graduate is to devise new methods for transmitting knowledge more efficiently.

²For the issues affecting compartmentalization see: James G. March and Herbert A. Simon, Organizations, John Wiley & Sons, Inc., 1963, Chapter 6, and Zenon S. Zannetos, "On the Theory of Divisional Structures: Some Aspects of Centralization and Decentralization of Control and Decision Making," Management Science, December 1965, Vol. 12, No. 4, Series B.

The pressures, however, do not only lie in the area of student concern. We also find that faculty members are hard pressed to choose between teaching and research. These pressures now threaten the fiber of some of the best institutions of higher learning in the United States and the intensity of the struggle for some kind of solution will become even greater in the future. In order that a professor specialize he needs to devote time to his research without interruptions. But if he is burdened with teaching a lot of pre-requisite courses, and given the fact that we have limited capabilities, at some point he has to make a compromise. If it becomes more and more difficult for him to make such a compromise then we will find that the professor will be forced to choose either to be a teacher of known material without any research interests or else devote most of his time, if not all, on research and not prepare for his classes. I am sure you heard of professors who consider teaching as the penalty they have to pay in order to do research, and think of students as a necessary evil. With the amount of new knowledge that we generate today, the reconciliation of these two duties, that is to say teaching and research, becomes very critical. Otherwise the polarization will occur on the power of natural forces.

So that I am not misunderstood, let me stress that I am not advocating curtailment of research and research orientation. What I am saying is, that in the absence of any mechanism to bridge the gap between the specialist teacher and the specialist researcher, both of whom we need, we will be cheating our students and not giving them the best education possible. What is more, and even if we can combine both excellent teaching and research qualifications in each and every professor, with no trade-offs, still the

greater the research orientation of a university, the more specialized and therefore compartmentalized will be the instruction. So the student and especially the undergraduate will be hopelessly confused and lost. That is why I feel that this aspect of management of the educational process, that is to say, the bridging of the gap between teaching and research and the integration of curricula is very challenging. And I hope that techniques such as programmed instruction can help us "have our cake and eat it too."

If we somehow could find a way to relegate to a system the repetitive material, and if furthermore we could be assured that the students could acquire the prerequisite knowledge effectively, then we can devote most of our classroom efforts to presenting material which is new and challenging to us. And therefore, teaching will not be any more a drudgery. Such a method has another advantage in that the rate of new knowledge will be accelerated. The professor under such a system, if it were devised, will be spending most of his time in introducing material which is at the frontier of the field and at some schools it will be the result of his own research.

Another area where some progress must be made, if integration of knowledge is to be achieved, is the fusion of the various disciplinary approaches to the subject matter. In the area of management, we have today several approaches to the problems facing the firm and unless we make some efforts to integrate these disciplinary approaches, unless we bring the proponents of these approaches together for a dialogue, we cannot have integrated interdisciplinary approaches to education.

I claimed, a few minutes ago, that programmed instruction can help us in my estimation in accomplishing many of these objectives in the future. This is true, but not by itself. We cannot do what I propose with programmed texts of the printed nature no matter whether these are of the Skinnerian or Crowderian type. In order to accomplish what I have in mind, we need

computers and especially new designs of computers, and techniques of pattern recognition and material content association.

IV. The Impact of the Computer

Most of the experiments which have been done so far with programmed instruction have used textbooks as the medium. The so-called teaching machines are mostly little desk devices which did not accomplish anything different than the programmed text. This applies also to computers which are being used as glorified teaching machines. The computer, however, has the potential to be used in a better capacity than just purely as a teaching machine. With the present state of technological developments, and with man-machine interaction schemes, computers afford us opportunities that we have not had in the past. Let us see why and how.

The present programmed instruction methods regiment the student to follow the procedures prescribed by the programmer. Whether the program is of the serial or branching type, the search procedure is inflexibly fixed and the student has to proceed in most cases from beginning to end. In order that we speed up the learning process and allow the student to use his imagination and devise his own learning schemes, we have to provide for flexible search procedures. By this I mean, procedures which will allow the student to question the program in terms of content and retrieve information on such basis. Now information is retrieved on the basis of location. One has to know the location where the information exists before he can retrieve it, and that is why the program takes the student through step by step, location by location from beginning to end in order to make sure that he acquires the material. Obviously such a procedure wastes the

time of the bright student unless some kind of a method of extensive indexing (of chaotic proportions) is provided at the end. But even so the student, on the basis of content he searches the index so that he may be referred to a location which will give him the information that he desires. This method has obvious limitations. Alternatively, and this is the method which I advocate, is to design flexible search patterns, which will allow the student to address the program on the basis of content and retrieve all the information that bears on the question that bothers him. Computers are a little by little acquiring this capability and can be of great help to us in accomplishing our objectives in this area.

On top of flexible search, we may introduce adaptive characteristics in the program itself. In other words, by means of interaction between the expert and the machine the program can be taught to learn from experience, recognize efficient search patterns, and on the basis of those patterns adapt itself sequentially as new uses of the system are made. A system, with flexible search procedures which is adaptive and recognizes search patterns, may then be able to guide the student toward more efficient search methods once it recognizes the objective of the student. I am sure you will agree that this procedure will save the student an extensive number of hours in his quest for knowledge.

Once the system succeeds in recognizing patterns, we can then associate the content of the various patterns with other patterns and therefore cut across (integrate) programs, again on the basis of content. Such an arrangement will provide the student with a complete pattern on the basis of the content of his request. This capability necessitates that the program itself allows at its various parts flexibility for logical operations in order that a pattern may be recognized and/or formed at the local level.

The hardware characteristics which will enable us to achieve what I am greatly advocating here are mainly of two types. (1) We need to have associative memory which associates on the basis of content and which searches in a parallel fashion rather than sequentially and (2) we must have capabilities for distributed logic in the sense that each module performs logical operations itself rather than refer the one who questions the system to an executive routine for further processing. This in effect is a decentralization of logic.³

Of course these characteristics of the computer that I mentioned, lie in the future. But already a lot of research is being done on cryogenic memories which have adaptive and pattern recognition characteristics as well as associative capabilities. If we succeed in the computer hardware area, then we can visualize a series of programmed instruction programs for the various core courses of our curricula being stored into the computer, and then a team of faculty members who sit at the console and try to teach the system to associate and recognize patterns on the basis of heuristics that they themselves follow in associating. After these elementary procedures, by means of which the computer is taught to learn, then through software the computer can be instructed to keep trace of the search patterns

³Some of the general characteristics of such systems are described extensively in Zenon S. Zannetos, "Toward Intelligent Management Information Systems" MIT Working Paper 155-65; "Toward the Realization of Intelligent Management Information Systems" by Donald C. Carroll and Zenon S. Zannetos, MIT Working Paper 218-66; "Some Thoughts on the Design and Implementation of Association Information Systems for Planning and Control" by Zenon S. Zannetos and Kenan Sahin, MIT Working Paper 220-66.

of the students and generalize on the basis of the requests made. In this way, the computer not only can guide the student toward more efficient search methods but can also provide the student with information that relates to the subject on which he is questioning, but which information he did not originally request, because he was not aware that it existed. This is briefly the procedure by means of which the student will be presented with an integrated pattern based on the content of his request. It will cut, as I already mentioned, across all the basic courses of our curriculum. It will associate, it will be interdisciplinary and therefore will enrich the students knowledge.

Such a system has great challenges for us as educators also. Not only it will provide us with the challenge of how to integrate our curricula, not only it will relieve us of the repetitive material which after a while becomes a drudgery, but will also allow us to cut out a lot of unnecessary redundancy. Very often we find that departments, groups or individuals teach material which is repetitive either because they do not know that it is taught elsewhere or in ignorance they feel that no one else can teach it as well as they do.

A computerized system with associative characteristics can easily detect redundancy in the material stored because it will bring it forth on the basis of requests bearing on that content. It will also enable us to introduce into the first courses that we teach, and I stress the first courses, material which is at the frontier of the profession at that time. The teacher-researcher, therefore, will not be handicapped. He can introduce into his courses the latest results of his research. This can be a real and exciting educational experience for both the teacher as well as the student. As soon

as the professor succeeds in routinizing or programming part of the material in which he is researching, in other words, as soon as he reduces enough ambiguity to make the material amenable to programming, then he can relegate it to the system and again relieve himself of repetitive material only to rise to a high level of abstract material at the next round.⁴ This process, of course, as you will recognize has no limit and it is here where the challenge lies. A process of continuous innovation, reduction of redundant and obsolete material, compression of the time period it takes to educate people and excitement of the imagination toward innovation. This is the challenge that lies ahead with programmed instruction and information technology as I see it.

⁴This, in effect, is a form of management by exception.

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